Bright attosecond electron beams and brilliant gamma ray sources with the Resonant Multi-Pulse Ionization Injection

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High-brightness e-beams with duration of a few hundreds of attoseconds can be employed either as direct probes or as drivers of Compton/Thomson backscattered X/γ photons beams having similar duration. We show, by means of theory and quasi-3D PIC simulations, that a GeV scale electron beam source having *rms* duration widely tuneable in the interval $100-2000\,as$ and with projected $6D$ brightness exceeding $B_{6D} > 10^{17} A/m^2/0.1\%$ and normalized emittances below $100\,nm \times rad$ can be obtained with the Resonant Multi-Pulse Ionization Injection (ReMPI) [1]. In the presented simulations setup a train of two/four pulses resonantly excite the plasma wave on a preformed plasma from a He-Ar mixture. A further tightly focused pulse in second/fourth harmonics, collinear with the train and properly delayed, extracts electrons from the K-shell of the Ar dopant ions placing them the the favourable phase of the wakefield so as to trap them thus obtaining a low residual transverse momentum [2] as in the Two Color ionization injection [3]. During the slippage in the bucket and up to the trapping point, the bunch length reduces down to tiny fractions of the initial one. The tuning of the beam duration is obtained by changing the delay between the ionization pulse. Compton/Thomson backscattering process simulations showed that quasi monochromatic attosecond X/γ beams with brilliance exceeding $10^{28} ph/s/mm^2 mrad^2/0.1\% bw$ can be obtained with current technology PW-class lasers.

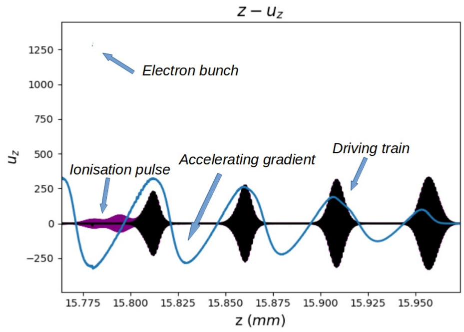

Figure 1: Wakefield excited by a train of four pulses. The $0.12\mu m$ long electron beam is visible on the top-left region of the longitudinal phase space $(z, u = p/mc)$ cut.

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